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PROFIT-DRIVEN DYNAMIC SPECTRUM ALLOCATION IN WIRELESS NETWORKS

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ABSTRACT

This paper focuses on the building of the dynamic spectrum allocation model in wireless networks. Considering the utilization of spectrum resources, base stations satisfaction and combining with the Coordinated Dynamic Spectrum Access modelit proposes a profit-driven dynamic spectrum allocation model and uses the genetic algorithm to get an approximate optimal solution

Keywords: *Wireless Networks; Collaborative Access Model; Spectrum Allocation; Genetic Algorithm.*

1. INTRODUCTION

At present, dynamic spectrum allocation methods in wireless networks can meet the spectrum resource allocation requirements within a certain rang. They are mainly based on the change of the spectrum resources in terms of time and geographical distribution. Relatively speaking, these allocation methods to make efficient use of spectrum resources have better adaptability than traditional ones. As traditional methods just make fixed allocation to the unities, it will get the idle spectrum wasted [1]. Until now,much works on dynamic spectrum allocation methods have been published. Su Xi proposed an adaptive dynamic spectrum allocation method in accordance with the prediction mechanism for the idle time of the detected narrow idle spectrum [2]. He Shibiao proposed Demand-driven Dynamic Spectrum Allocation model to get the main solution of the high efficiency of the dynamic spectrum resource utilization [3]. Huang Liya used game model to solve the dynamic allocation problem [4]. Deng Shuguang proposed a DSA-CP scheme for allocating spectrum[5]. Zhang Wenzhu adopted multi-winner auction in DSA issue[6]. Shi Hua got a effective allocation solution through clone selection algorithm[7]. The above findings have their own advantages, but do not take the efficiency and effectiveness of Spectrum Allocation into consideration together .and this paper proposes a new solution through combining this two aspects.

The remainder of this paper is organized as follows: Section 2 builds a system model combining with efficiency and effectiveness. Section 3 uses GA to solve the proposed model and gives the simulation results. Section 4 concludes the paper and puts forward the future directions.

2. SYSTEM MODEL

2.1 Model Description

The adapted spectrum allocation process is accordance with the Coordinated Dynamic Spectrum Access model [1]:the Spectrum Centre Manager assigns a certain range spectrum to the base stations in a specific area. Each base station can run one or multiple wireless networks. Well-known GSM Network adapts this operation mode. Interference exists in every two of the base stations. This paper uses Physical interference model to describe it. Base station can only run well when it meets the interference constraints. That is the received SINR (Signal to interference plus noise ratio) must be greater than threshold α [8].so, it is essential to get the minimize value of α .The formula is:

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$$\min V_{i,j} = \frac{p_i / r_i^{\beta}}{T + \sum_{i \neq j} b_{i,j} \cdot p_j / d_{i,j}^{\beta}} \quad (1)$$

p_i: transmission power of base station i; T: noise power; r_i: communication radius; $d_{i,j}$: the shortest distance between the coverage area of base station i and j. β: path loss factor.

On this basis, the spectrum recourse will be divided into N channels for the later allocation. In the model, it has S base stations and N channels needs to be allocated. F means a spectrum allocation example. $F(S,N)=\{x_{i,j}\}$, $x_{i,j}=[0,1]$, $i \in [1,S], j \in [1,N]$.

$$x_{i,j} = \begin{cases} 1 & \text{ssign channel j to base station i} \\ 0 & \text{the opposite result} \end{cases} \quad (2)$$

2.2 Model Construction

The model objective function is to calculate the maximum benefit of base stations in a certain area. It is effected by three aspects: 1) the benefit of base station meeting the demand;2) the cost brought by low utilization of spectrum;3)the cost brought by low degree satisfaction of base station.

The benefit of base station meeting the demand

The benefits that base station i gains from the assigned spectrum is:

$$P_i = \sum_{j=1}^{N} r_{ij}$$

(3)

r_{ij} means the benefit that Base station i gains from the assigned spectrum j.so the benefit of all base stations is:

$$E = \sum_{i=1}^{S} P_i$$

(4)

2.3 The Cost Brought By Low Utilization Of Spectrum

If spectrum resources obtained by the base station are lower than the total spectrum, it forms idle spectrum, which will bring the costs. This condition can be described by the normalized spectrum utilization .then to consider how the index connects with cost. It introduces parameter μ_1 to show the affection degree on the cost caused by the index, the formula is:

$$C_1 = \mu_1 Y_F ; Y_F = \frac{\sum_{i=1}^{S}\sum_{j=1}^{N} x_{i,j}}{SN} \quad (5)$$

2.4 The Cost Brought By Low Degree Satisfaction Of Base Station

If the base station don not get enough, it will indirectly led to a reduction in business volume with the result of reduction in benefit. That is opportunity cost. Similarly, it should introduce parameter μ_2 to show affection degree on the cost caused by base station satisfaction.

Assume that the spectrum demand of each base station is q_i, then the base station satisfaction is:

$$W_i = \min(q_i \Big/ \sum_{j=1}^{N} x_{i,j}, 1) \quad (6)$$

To simplify the problem, the degree of the impact on each base station is the same. The total opportunity cost is:

$$C_2 = \sum_{i=1}^{S} \mu_2 W_i$$

(7)

So, the objective function is:

$$\max E(F) = \max(E - C_1 - C_2)$$
$$= \max(\sum_{i=1}^{S} P_i - \mu_1 Y_i - \sum_{i=1}^{S} \mu_2 W_i) =$$
$$\max \begin{pmatrix} \sum_{i=1}^{S}\sum_{j=1}^{N} r_{ij} - \mu_1 (\sum_{i=1}^{S}\sum_{j=1}^{N} x_{i,j} \Big/ SN) \\ -\sum_{i=1}^{S} \mu_2 \min(q_i \Big/ \sum_{j=1}^{S} x_{i,j}, 1) \end{pmatrix}$$

(8)

3. MODEL SOLUTION

3.1 Method Description

The model is complex and it has to use intelligent algorithm to make a efficient calculation. So, this paper uses genetic algorithm to find the approximate optimal solution. The genetic algorithm is a randomized search method[9], which based on the genetics mechanism of biological evolution, and selects the solution of the model in accordance with the principle of survival of the fittest. Its characteristics include:

String set as the search range

less auxiliary information

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strong fault-tolerant capability

random search behavior

Implied parallel

In the model, operations of the genetic algorithm are as follows[10]:

s1． Gene encoding: the gene encoding uses binary encoding Every N bit describe the spectrum allocation strategy of a base station. Encoding format is shown in Table 1.

In table 1， the second line represents S base stations， there are N channels below each base station， the third line shows which channel is assigned to the base station

Table 1. Encoding Format

encoding format			
1	2	……	S
1 2 3 … N	1 2 3 … N	……	1 2 3 … N
1 0 1 … 1	1 1 0 … 0	……	1 0 0 … 1

s2. Choose an initial population: Use the roulette method to generate a population.

s3. Determine the fitness of each individual: use fitness function to judge the merits of the individual. The function is:

$$f(m) = \max E(F) + 10000 \min[(V_{i,j} - \alpha), 0] \quad (9)$$

s4. Perform selection: select individuals which are more adaptive to produce next generation.

s5. Perform crossover: individuals of population mate according to a certain crossover probability.

s6. Perform mutation: each individual generate mutation according to a certain mutation probability. Return to step s3.

s7. End computing: get the fitness individual according to the largest fitness.

3.2 SIMULATION ANALYZE

Tabel 1 shows the simulation parameters:

Table 1 Simulation Parameters

Parameter name	Parameter value
Spectrum amount	40
Square	(2000m,2000m)
Communication radius	50m
Pass loss factor	2
Transmission power	5db
SINA threshold	10db
Noise power	-102.5db
Base station demand	1~10
Base station location	Random selection
Base station amount	10
r_{ij}	100~200
μ_1	0.8
μ_2	0.8

As know that GA has no optimum result，so this paper repeats experiments ten times to get the final benefit as show in table 2：

Table 2 Ten Times Benefits

3560	3611	3554	3714	3621
3490	3495	3574	3558	3612

And table 3 show the allocation solution when the benefit is 3560.

Table 3 One Allocation Solution

Base station	Spectrum number
1	2、8、11、16、17、28、30
2	3
3	21、33、36
4	no
5	4、7、19、24、29、31、37
6	6
7	5、9、10、13
8	1、22、32、38、39
9	12、15、26、27、34
10	14、40

Analyze: Through the genetic algorithm, we can get the final spectrum resources allocation strategy. That includes the amount of spectrum every base station gets and the total profit of base stations as well as the respective profit. Besides, the further calculation of the utilization of spectrum resources and the satisfaction of every base station will play a

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part in the analysis of the characteristics of local demand.

4. CONCLUSIONS

It is an advantage of the model to take the utility evaluation both based on revenue and network properties into consideration to avoid imbalance of the spectrum allocation. And the genetic algorithm can find the solution quickly but not optimum. Solution results need to be further confirmed. In addition, how to set the value of μ_1 and μ_2 should be considered carefully as they are closely related to environmental factors. In short, the model provides a new study thinking for spectrum allocation. And for the more accurate analyze, the next research directions contain the consideration of the operation environment of signal base station.

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